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Application of Microbial Extracellular Polymeric Substances on the Growth and Yield of Sweet Corn (Peaches and Cream)

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Abstract

Microbial extracellular polymeric substances (EPS) have been shown to enhance soil structure, nutrient availability, microbial activity, and plant root development. It was therefore hypothesized that they could serve as a valuable natural resource for increasing agricultural productivity. This study investigated the effects of *Rhizobium tropici*-derived EPS on the growth and yield of sweet corn (Peaches and Cream) on soil freshly amended with EPS and in rotation following the cultivation of Black-eyed peas (BEP) on EPS-amended soil. Microbial EPS without BEP increased available soil phosphorus (avP), soil pH, Nitrate-N, and cation exchange capacity (CEC). Moreover, EPS increased sweet corn plant height, fresh and dry biomass, and improved ear formation and seed yield. Fresh EPS application boosted seed yield by 18.4%, while the residual effects of EPS and BEP increased sweet corn yield by 22.8%. The residual effects of EPS and BEP alone raised seed yield by 7.0% and 15.8%, respectively. We conclude that microbial-derived EPS can serve as a biofertilizer to promote the growth of BEP and sweet corn in crop rotation, offering a sustainable alternative to chemical fertilizers. This study emphasizes the potential role of microbial EPS in environmentally friendly agriculture.

Keywords

Extracellular Polymeric Substances (EPS), Black-Eyed Peas (BEPs), Sweet Corn, *Rhizobium tropici*

1. Introduction

Synthetic or chemical fertilizers are often applied to soils faster than plants can use them. The excess can enter the atmosphere as greenhouse gases or be washed into waterways, causing algal blooms that deplete oxygen and kill fish. The use of organic amendments, either as the sole fertilizer source or as a complement to synthetic fertilizers, is gaining popularity in sustainable agricultural practices for their positive effects on soil physical properties and the growth of useful microorganisms that mineralize organic matter.

Isolated microbial extracellular polymeric substances (EPS) are favored as biofertilizers because they are effective at low soil concentrations (≤0.1% w/w) [1] [2], and their use avoids the drawbacks of introducing foreign microorganisms or synthetic microbial consortia (SynComs) into agriculture. Microbial EPS are a complex mix of excretory products—mainly polysaccharides, proteins, lipids, and extracellular nucleic acids—produced by soil microbes as part of biofilms to survive in the environment [3]. Methods have been developed to produce crude or purified EPS in the lab, involving culturing microorganisms in selective media, modifying, precipitating, and drying the biopolymer into a salt that can be reconstituted in water [4]. *Rhizobium tropici*, a legume symbiont, is known for its high EPS production capacity [5]. *R. tropici*-derived EPS have been shown to improve soil aggregate stability, water retention, active carbon, and mineralizable nitrogen, as well as phosphorus solubility and bioavailability, enhancing nutrient retention, plant root development, and legume root nodulation [6]. Due to their positive impact on soil structure and nutrient availability, microbial EPS are hypothesized to be a valuable natural resource for increasing agricultural productivity. This study aimed to evaluate the effects of *R. tropici*-derived EPS on the growth and yield of sweet corn in monoculture and in rotation after growing Black-eyed peas on EPS-amended soil.

2. Materials and Methods

2.1. Study Site, Experimental Design, EPS Applications, and Seeding

The evaluation of the effect of microbial extracellular polymeric substances (EPS) on the performance of sweet corn was carried out in three separate experiments.

Experiment 1: Residual Effects Field Study. The first experiment was a field study in which sweet corn was grown in rotation after Black-eyed peas (BEP, *Vigna unguiculata*) on EPS-amended soil. The study evaluated the residual effects of EPS and BEP on sweet corn performance. The soil was amended with 0.1% (w/w) *R. tropici*-derived EPS (ATCC® 49672™) and planted with BEP. The study was conducted at the Winfred Thomas Agricultural Research Station (WTARS), Alabama A&M University (GPS coordinates: 34.90136˚N, 86.55971˚W (WGS84)). The soil is classified as Decatur silt loam (Fine, kaolinitic, thermic Rhodic Paleudult). The typical climate is humid subtropical, with hot summers and relatively mild winters, occasionally including cold days with temperatures below freezing. The mean daily air temperature and precipitation during the crop-growing period, March to August, were 20.1˚C and 3.9 mm for 2023, 21.2˚C and 4.4 mm for 2024, and 20.7˚C and 4.7 mm for 2025 at WTARS. The variation in air temperature and rainfall during the growing season is illustrated in **Figure 1**.

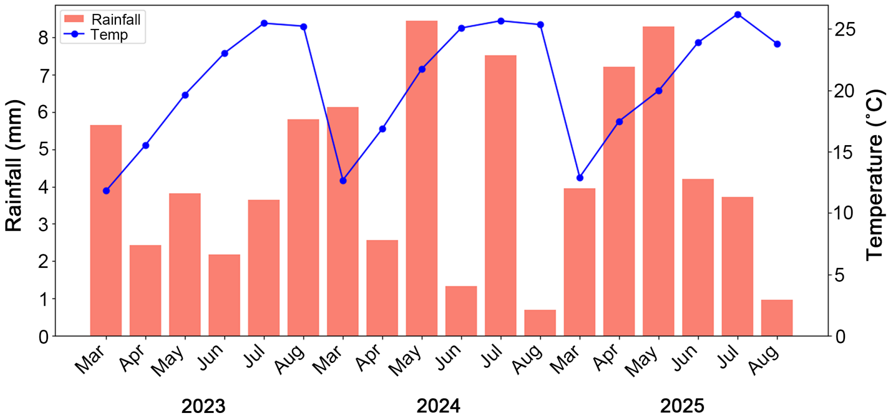

Figure 1. Monthly average air temperature and rainfall at the Winfred Thomas Agricultural Research Station from March to August in 2023, 2024, and 2025.

In 2023, the land was mowed and plowed before applying the EPS solution (10 g/L). The experimental design with 3 blocks and 4 plots per block was a Randomized Complete Block Design (RCBD) with an experimental size of 16 × 30 m. The first plot (Plot 1) was amended with EPS but not planted with BEP. The second plot (Plot 2) had EPS and Black-eyed peas, the third plot (Plot 3) had Black-eyed peas only, while the fourth plot (Plot 4), or control, was without EPS and Black-eyed peas. The block size was 16 × 10 m, while the plot size was 4 × 10 m. In three split applications, *R. tropici* EPS solution was added to the soil at 0.1% (w/w) at 10 cm depth. An equivalent volume of tap water was added to the control plot without EPS. The experiment was repeated in 2024 on the same plots. The 0.1% EPS amount was selected because, in a previous greenhouse experiment, Decatur silt loam soil was amended with 0%. 0.02%, 0.1%, and 0.5% EPS (w/w), microbial biomass, and root biomass were significantly reduced at 0.5% compared to the control, whereas 0.1% EPS increased shoot and root biomass as well as microbial biomass [2]. The effects of the EPS on soil properties and the growth and yield of the BEP were evaluated. BEP seed yield was estimated as

$$\text{Yield/ha} = \text{pods/plant} \times \text{seeds/pod} \times \text{mass/seed} \times \text{plants/ha} .$$

In 2024, Plots 1 and 2 were again amended with 0.1% EPS, and BEP were planted on Plots 2 and 3. In 2025, sweet corn (Peaches and cream) was planted on the plots (Plots 1, 2, 3, and 4) in rotation without any further application of EPS. The sweet corn seeds were obtained from Madison Cooperative, Huntsville, Alabama. Seed spacing was maintained as 25.4 cm (10 inches) between plants and 76.2 cm (30 inches) between rows at a planting depth of 2.54 cm (1 inch). There were 5 rows per plot and 40 plants per row. Seedling emergence was monitored each day for 10 days, while growth data was collected every two days at the early stages of plant growth and weekly at tasseling and silking stages. The seed yield parameters were collected at maturity, including the number of ears per plant, rows per ear, kernels per row, ear mass, ear diameter, and ear length. Sweet corn seed yield was estimated as follows:

$$\text{Yield}\left(\text{mass/ha}\right) = \text{plants/ha} \times \text{ears/plant} \times \text{kernel rows/ear} \times \text{kernels/row} \times \text{mass/kernel}.$$

Experiment 2: Greenhouse Pot Study. The second experiment was a greenhouse study to verify the soil concentrations of applied microbial EPS for optimal sweet corn growth. Sieved (2 mm) Decatur silt loam soil (7.6 kg oven-dry weight) was amended with different amounts of *R. tropici*-derived EPS (0%, 0.05%, 0.10%, and 0.15% w/w). The required amounts of EPS were thoroughly mixed with the soil in cylindrical black polyethylene pots (22 cm diameter × 21 cm height), each with six holes at the bottom, and the soil moisture was maintained at 25%. Five (5) sweet corn seeds were planted in each pot. There were 8 pots per treatment, giving a total of 40 seeds that were allowed to germinate. Ten days after planting, the most viable (healthiest-looking) sweet corn seedling in each pot was allowed to continue growing, while the rest were removed, leaving 8 plants per treatment. The number of seeds that germinated during the experiment was recorded. The soil moisture content was maintained by weighing the potted soil every two days, and any weight loss was compensated for by adding the equivalent amount of water. The pots were rotated every 2 days to minimize the effects of the plants' phototropic response. The daytime greenhouse temperatures ranged from 24˚C - 30˚C, while the nighttime temperatures ranged from 18˚C - 21˚C. The plant growth parameters were collected at the tasseling stage.

Experiment 3: Fresh EPS Application Field Study. The third experiment was a field study to evaluate the effects of applying fresh microbial EPS to soil on the growth and yield of sweet corn. In 2025, a contiguous plot (13 m × 13 m) adjacent to the first field experimental plots at WTARS was amended with fresh EPS (0.15% w/w) and planted with sweet corn. An equivalent amount of tap water was used in place of EPS in the control plot of the same size. The same plant and row spacing were maintained as in the first field experiment, with each plot containing 17 rows and 50 plants per row. The 0.15% EPS concentration was selected for the amended plot for field studies because results from the greenhouse experiment, which tested 0%, 0.05%, 0.1%, and 0.15% EPS, showed that plant growth parameters were best at 0.15% EPS-soil fortification. The growth and yield of crops on EPS-amended and unamended soils were compared.

In the field experiments, the crops were allowed to grow under natural rainfall without irrigation, and weeds were removed manually without herbicide application.

2.2. Soil Chemical Analysis

Soil samples were collected from four different locations in each plot at 0 - 15 cm depth to form a composite sample for the treatment and analyzed for soil pH, soil organic matter (SOM) [7], exchangeable bases, cation exchange capacity (CEC), nitrate [8], available phosphate [9], total nitrogen (TN) [10], and permanganate oxidizable carbon (POx-C) [11]. Each analysis was in triplicate.

2.3. Statistical Analysis

Data on the residual effects of EPS and BEP on soil properties and the yield of sweet corn were analyzed by analysis of variance (ANOVA) test and Tukey's test to assess the significance of the differences between treatments using SAS 9.4 for Windows (SAS Institute Inc., Cary, NC, USA). Data on the growth and yield of sweet corn on fresh EPS-amended and unamended soils were analyzed using two-sample t-tests, assuming equal variances.

3. Results

3.1. Effects of EPS on the Growth and Yield of Black-Eyed Peas in the Field

Black-eyed peas were grown in the field on soils amended with EPS for two consecutive years, 2023 and 2024. The results showed that after the first growing season (2023), the seed yield of BEP increased. In the second growing season (2024), whereas the vegetative yield increased by 56%, the seed yield decreased by 89% (Table 1). Also, the average root nodule counts per plant (RNCPP), the number of branches per plant (BPP), the number of pods, the number of seeds per pod, and pod mass were greatly reduced in 2024 compared to 2023.

Table 1. (a) Effect of EPS on Black-eyed peas growth parameters: average stem height (SH), number of branches per plant (BPP), root length per plant (RLPP), root nodule counts per plant (RNCPP), shoot dry mass (SDM), and root dry mass (RDM); (b) Effect of EPS on the seed yield parameters of Black-eyed peas.

(a)

Year of soil treatment with EPS	Growth parameters of Black-eyed peas						
	SH (cm)	BPP	RLPP (cm)	RNCPP	SDM (g)	RDM (g)	RDM:RDM
2023	44.0	3.9	14.4	25.3	26.8	1.4	0.06
2024	179.7	1.8	21.0	20.4	41.9	2.6	0.06
% Change	308.4	−53.9	45.8	−19.4	56.3	85.7	0

(b)

Year of soil treatment with EPS	Seed yield parameters of Black-eyed peas					
	Average branches per plant	Average pods per plant	Average seeds per pod	Average pod mass (g)	Average seed mass (g)	Seed yield (kg/ha)
2023	3.9	24.6	7.7	2.2	0.23	3827
2024	3.5	4.6	4.9	1.8	0.18	418
% Change	−10.3	−81.3	36.4	−18.2	−21.7	−89.1

3.2. Effects of EPS and Black-Eyed Pea Growth on Soil Properties

To assess the effects of EPS application and BEP growth on soil properties, soil samples were collected from four locations in each plot and combined to form a composite sample. Table 2 presents the soil properties after the first EPS application and BEP harvest. Table 3 shows the soil properties after the second EPS application and BEP development. The results indicated that both EPS and BEP significantly increased soil N and active C. The combined impact of EPS and BEP on these soil parameters was greater than each one alone. Additionally, both EPS and BEP increased soil organic matter (SOM), although not significantly. Moreover, EPS without BEP boosted available soil phosphorus (avP), soil pH, NO_3^--N, and cation exchange capacity (CEC). BEP had a minimal effect on CEC. The findings revealed a significant increase in soil N after the second year of BEP growth on both EPS-treated and untreated soils (Table 3).

Table 2. Residual effects of EPS and BEP on soil properties after the first EPS application (2023).

Treatment	pH	SOM %	CEC (meq/100 g)	NO_3^--N	avP	Total N	Active C
				ppm			
EPS	6.5^a	4.6^a	14.3^a	43.7^a	41.2^a	1834^a	689.9^a
EPS + BEP	6.4^a	4.6^a	14.1^a	23.5^c	35.5^{ab}	1870^a	765.8^a
BEP	6.3^a	4.5^a	10.8^b	18.2^c	34.6^{ab}	1820^a	734.7^a
Control	6.2^a	4.4^a	10.8^b	34.0^b	28.1^b	1784^b	609.5^b

Values (means for each parameter) with similar letters indicate not statistically different based on Tukey's Studentized Range (HSD) comparison with $\alpha = 0.05$.

Table 3. Residual effects of EPS and BEP on soil properties after the second EPS application (2024).

Treatment	pH	SOM %	CEC (meq/100 g)	NO_3^--N	avP	Total N	Active C
				ppm			
EPS	6.6^a	4.7^a	15.1^a	45.2^a	43.8^a	2089^b	678.7^a
EPS + BEP	6.4^a	4.8^a	14.6^a	26.5^c	36.6^{ab}	2899^a	798.4^a
BEP	6.3^a	4.6^a	10.9^b	25.4^c	35.1^{ab}	2544^b	756.5^a
Control	6.2^a	4.4^a	10.8^b	34.1^b	27.3^b	1795^c	612.3^b

Values (means for each parameter) with similar letters indicate not statistically different based on Tukey's Studentized Range (HSD) comparison with $\alpha = 0.05$.

3.3. Residual Effect of EPS and BEP Growth on the Performance of Sweet Corn in the Field

In a field study, sweet corn was planted on plots previously amended with EPS and or planted with BEP after two planting seasons to assess the residual effects of EPS and BEP on the growth and yield of sweet corn. The highest sweet corn grain yield was obtained on the plot previously amended with EPS and planted with BEP. The yield increased by 22.8%, whereas EPS and BEP increased by 7.0% and 15.8%, respectively, compared with plants grown on the control plot (**Table 4**). The greatest contributor to the differences in grain yield was the number of kernels per row. Although EPS increased the sugar content (Brix value) of the sweet corn grains, the increase was not significant.

Table 4. Sweet corn yield parameters as affected by EPS soil amendment and Black-eyed peas growth.

Treatment	Ears/plant	Kernel rows/ear	Kernels/row	Mass/Kernel	Sweet corn yield (MT/ha)	% Yield Increase	Brix %
EPS	1^a	16.8^a	30.5^c	0.26^a	6.1^c	7.0	25.6^a
EPS + BEP	1^a	17.1^a	34.7^a	0.26^a	7.0^a	22.8	24.2^a
BEP	1^a	16.8^a	33.0^b	0.26^a	6.6^b	15.8	24.6^a
Control	1^a	16.5^a	29.0^d	0.26^a	5.7^d		24.5^a

Values (means for each parameter) with similar letters indicate not statistically different based on Tukey's Studentized Range (HSD) comparison with $\alpha = 0.05$.

3.4. Effect of Fresh EPS Soil Amendment on the Growth of Sweet Corn

Sweet corn was planted in the greenhouse in pots filled with soil freshly amended with varying levels of EPS. The results indicated that the greatest plant biomass was obtained for soils amended with 0.15% EPS (w/w) (**Table 5**).

Table 5. Effect of EPS on sweet corn growth in the greenhouse.

Treatment	Shoot dry mass (g)	Root dry mass (g)	Plant height (cm)	Plant girth (mm)	Leaf area (cm^2)
0.15% EPS	10.57^a	0.33^a	95.88^a	9.76^a	1288.4^a
0.1% EPS	8.95^{ab}	0.20^{ab}	84.85^{ab}	8.65^a	1101.1^a
0.05% EPS	8.37^b	0.14^b	75.88^b	8.30^a	1022.5^a
0% EPS	8.15^b	0.13^b	74.83^b	7.51^a	908.0^a

Values (means for each parameter) with similar letters indicate not statistically different based on Tukey's Studentized Range (HSD) comparison with $\alpha = 0.05$.

In a separate field experiment, sweet corn was planted on soil amended with EPS. The results showed that when freshly applied to soil, EPS significantly increased several sweet corn growth and yield attributes (**Table 6**). At 0.15% (w/w) in soil, *R. tropici*-derived EPS increased the grain yield by 18.4% (**Table 6(b)**). However, EPS has little or no effect on the number of ears per plant and mass per kernel, which were 1.0 and 0.26 g, respectively for both sweet corn grown on EPS-amended and untreated soils.

Table 6. (a) Sweet corn growth parameters for amended and unamended (control) soils; (b) Sweet corn grain yield parameters for amended and unamended (control) soils.

(a)

Soil incubation	Mean growth attributes of sweet corn					
	Plant height (cm)	Stem diameter (cm)	Leaves per plant	Leaf length (cm)	Root length (cm)	Root biomass (g)
0% EPS	99.96	13.13	9.5	55.69	16.43	8.91
0.15% EPS	126.76	15.43	9.9	65.98	19.12	11.82
t statistic (df)	6.4 (168)	10.2 (168)	3.4 (168)	11.3 (168)	6.7 (168)	4.4 (168)
p-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

(b)

Soil treatment	Mean yield attributes of sweet corn								
	Ears per plant	Rows per ear	Kernels per row	Ear Mass (g)	Ear length (cm)	Ear diameter (mm)	Brix (%)	Sweet corn yield (MT/ha)	% Yield Increase
0% EPS	1.0	15.25	25.9	106.63	11.58	36.69	24.14	4.9	
0.15% EPS	1.0	15.86	29.3	140.98	13.43	39.27	25.35	5.8	18.4
t statistic (df)		2.1 (168)	4.0 (168)	5.9 (168)	5.2 (168)	3.0 (168)	1.2 (26)		
p-value		0.018	<0.001	<0.001	<0.001	<0.001	0.117		

p-values more than 0.05 indicate no significant effect of EPS soil application on the plant growth parameters.

4. Discussions

This study aimed to evaluate the potential of using microbial EPS as a sole biofertilizer for sweet corn growth in sustainable, environmentally friendly agriculture. Sweet corn is grown worldwide for its nutritional value and economic importance in the food, pharmaceutical, and agropastoral industries [12] [13]. Growing sweet corn after Black-eyed peas is a crop rotation strategy because BEP enriches the soil with nitrogen needed for healthy corn growth and breaks the pest and disease host cycle. Black-eyed peas form a symbiotic relationship with Rhizobia bacteria in their root nodules, which fix nitrogen from the atmosphere. When the pea plants die, the stored nitrogen is released into the soil, directly feeding the subsequent corn crop [14]. Microbial-derived EPS promote root nodulation and seed yield of BEP [2] [15], increasing their potential to enrich the soil with nitrogen. In this study, sweet corn was grown in the field on plots previously amended with *R. tropici*-derived EPS and or planted with BEP to evaluate the residual effects of amending soils with EPS and growing with BEP on the growth and yield of sweet corn. In a second field experiment, sweet corn was grown on plots freshly amended with EPS, and the yield parameters were compared with those of untreated plants.

4.1. Residual Effects of EPS and BEP Growth on Soil Properties and the Performance of Sweet Corn

Sweet corn grain yield was highest in plots previously amended with EPS and planted with BEP, compared to plots with only EPS and BEP, as well as the control plot (**Table 4**). This is likely due to the positive effects of EPS and/or BEP on soil properties. EPS increased soil pH, SOM, CEC, available soil P, total N, and nitrate N (**Table 2** and **Table 3**). This increase in soil nutrient status in EPS-amended soils explains the increase in sweet corn yield, notably, the increase in the number of kernels per row (**Table 4**). While BEP had minimal or no impact on soil pH and CEC, it did increase soil N. Nitrogen and phosphorus are two crucial macronutrients necessary for sweet corn growth and yield [16]. EPS raised soil pH, creating a more favorable environment for nitrogen-converting bacteria, which coexist with BEP roots. Nitrogen promotes rapid leaf and stem growth, while phosphorus is essential for energy transfer, root development, stalk strength, and kernel formation [17] [18]. Although most soils contain substantial total P stocks, only a small portion of inorganic and organic P is dissolved at any given time [19]. Phosphorus activators are believed to enhance soil available phosphorus by stimulating phosphate-solubilizing bacteria (PSB), which release organic acids and solubilize inorganic P [20] [21]. Previous microbiome studies of EPS-amended Decatur silt loam soil identified Bacillus and Gaiella as dominant genera, which are important for soil ecosystem stability and nutrient cycling [22]. However, some research indicates that in certain ecosystems, high EPS concentrations in soil may trap P, decreasing its immediate bioavailability [23]. Our findings suggest that *R. tropici* EPS can act as a P activator at amounts equal to or less than 0.15% (w/w) in soil. The decline in available soil P and nitrate N in soils amended with EPS and planted with BEP, compared to EPS alone (**Table 2** and **Table 3**), may result from plant uptake. Although microbial EPS has been shown to adsorb onto soil minerals and organic particles during P solubilization [24] [25], the exact mechanisms relating microbial EPS to the release of available soil P from soil P stocks require further investigation. However, the anionic groups (specifically carboxyl and phosphate) in microbial EPS have been shown to chelate phosphate-precipitating cations (e.g., Ca^{2+}, Al^{3+}) effectively trapping them in the EPS matrix [26]. This may explain in part the increase in available soil P in EPS-amended soils.

The study also shows that microbial EPS significantly increased soil cation exchange capacity (CEC) after two years of incubation, which corresponded to higher sweet corn yield. This may be attributed to the abundant anionic functional groups—primarily carboxyl, hydroxyl, and phosphoric groups that act as binding sites for metal cations [27]. These groups may also play a role in regulating soil acidity for healthy sweet corn growth in the acidic Decatur silt loam soil.

The decrease in BEP seed yield and root nodulation (**Table 1**) coincided with a significant increase in soil nitrogen after the second consecutive BEP season (**Table 3**). Although nitrogen is normally an essential nutrient for BEP growth, excessive soil nitrogen led to lush vegetative growth, likely diverting energy away from flowering and pod formation. Similar results, with nitrogen suppressing legume root nodulation and seed yield despite healthy vegetative growth, have been reported in the literature [28]. This highlights that for legumes, more nitrogen does not equal more yield, and excessive soil nitrogen can be detrimental to the current crop. However, our results showed that the residual effect was beneficial for the growth and yield of the next crop, sweet corn. Due to the drastic drop in BEP seed yield after the second growing season, we recommend the planting of sweet corn after the first season of BEP growth on EPS-amended soils, for maximum economic benefits of both crops.

4.2. Effect of Fresh EPS on the Performance of Sweet Corn

In the greenhouse experiment, the highest sweet corn biomass was achieved with soils amended with 0.15% (w/w) EPS (**Table 5**). Previous studies with BEP indicated that plant growth and microbial biomass were optimal at an EPS soil level of 0.10% (w/w) [2]. This suggests that the optimal amount of EPS in soil for maximum crop growth and yield may vary depending on the crop type. When Decatur silt loam soil was freshly amended with EPS, the grain yield of sweet corn was 5.8 metric tons per hectare (MT/ha), compared to 7.0 MT/ha for sweet corn grown on soil previously amended with EPS and grown with BEP (**Table 4** and **Table 6**). This indicates that planting sweet corn in rotation after the growth of BEP on EPS-amended soil might be more effective than using fresh EPS. In this study, sweet corn was planted after two consecutive years of soil enrichment with EPS and cultivation of BEP. The results showed that although the vegetative yield of BEP increased in the second growth season, the seed yield and root nodule count dropped notably (**Table 1**). This suggests that, for maximum economic benefits, sweet corn should be planted in the season following the growth of BEP on EPS-amended soil. Although microbial EPS has been reported to increase the sugar content of corn, especially under stress conditions [29], our study found that EPS and/or BEP had little or no effect on the Brix value (sugar content) of sweet corn (**Table 4** and **Table 6**). This might be because peaches and cream is a variety of sweet corn with very high sugar content.

5. Conclusions

Our findings underscore the effectiveness of using microbial EPS as a biofertilizer in the growth of sweet corn. Sweet corn yield on freshly EPS-amended soil was 5.8 MT/ha, while the yield of corn on soil previously amended with EPS and grown with BEP was 7.0 MT/ha. Microbial EPS enhanced the ability of BEP to enrich the soil. At concentrations equal to or less than 0.15% (w/w), soil EPS is a potential P activator beneficial for the growth of corn. We recommend the use of *R. tropici*-derived EPS in crop rotation farming practices where sweet corn is grown after BEP.

While microbial-derived EPS showed benefits in terms of yield enhancement of BEP and sweet corn, over one or two growing seasons, this study was carried out in a single location representing one soil type and within a relatively short period of time. There is a need for multi-year and multi-location trials to validate the results and for broader application of microbial-derived EPS in crop production. We are continuing long-term field trials and data collection to further validate its impact over multiple growing seasons. Additionally, future trials will be run by focusing on the use of EPS to coat seeds before planting, applying the EPS on the root zone rather than spreading it on the whole field, integration of EPS in mixed cropping, and evaluating the cost-benefit analysis of using microbial EPS in sustainable agriculture systems.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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